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Markets

THE CLOVER AND ALFALFA SEED CHALCIS-FLY.[1]

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INTRODUCTION.

The chalcis-fly *Bruchophagus funebris* How. belongs to a group or superfamily of Hymenoptera known as Chalcidoidea. The habits of this species differ considerably from the general habits common to most of the other members of this group. Many of the Chalcidoidea are parasitic Hymenoptera, feeding, in the larval stage, upon various forms of insect life. *B. funebris*, on the other hand, is strictly phytophagous, and feeds within the growing seeds of alfalfa and red clover. This insect has for many years been a pest of clover seed throughout the Middle Western States, and has become generally known as the clover-seed chalcis-fly. The increased production of alfalfa seed throughout the Western States was followed by the rapid development of this insect in nearly all of the alfalfa seed-growing districts of the United States, so that at the present time it is the most destructive pest of alfalfa seed. The injury done is known to many farmers as "blighted seed," but this insect is now becoming more generally known among alfalfa-seed growers as the alfalfa-seed chalcis-fly.

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[1] In the summer of 1912 the writer was detailed to make a study of the alfalfa-seed chalcis-fly (*Bruchophagus funebris* How.), and different phases of these investigations have been continued up to the present time, most of them being conducted in the seed districts of California, Arizona, and Utah. The author's studies of the distribution of this insect and its parasites have been greatly assisted through the kindness of various members of the branch of Cereal and Forage Insect Investigations, and by Mr. Roland McKee, of the Office of Forage Crop Investigations, Bureau of Plant Industry. Special credit is due Messrs. R. N. Wilson, C. N. Ainslie, V. L. Wildermuth, E. G. Kelly, T. H. Parks, and H. T. Osborn, who made many personal field observations in connection with the life-history studies of this insect. The writer is also greatly indebted to Mr. A. B. Gahan for his kindness in making determinations of several new parasites of *B. funebris*.

HISTORY AND SYNONYMY.

This species was described by Dr. L. O. Howard[1] as *Eurytoma funebris.* It was for some years supposed to be a parasite of the clover-flower midge, *Dasyneura laguminicola* Lintner. The original description is as follows:

> *Male.*—Length of body 1.7^{mm}, expanse of wings 2.5^{mm}. Head slightly wider than thorax; antennæ nearly as long as thorax; flagellum of antennæ 6-jointed (counting the club as 1 joint); joints very strongly incised from above, subequal in length except club and first joint; each joint, except club, with two whorls of yellowish hair, each whorl as long as the joint. Top of head and thorax coarsely punctured, and covered with sparse and very short whitish hair. Subcostal vein yellowish and strong, reaches costa a little before the middle of the wing, and almost immediately gives off stigma; stigma with a small club and faint indication of a branch. Peduncle very strong and not long; abdomen very small, less than half the length of the thorax. General color black, eyes dark brown, knees, anterior tibiæ, all tarsi light brown.
>
> *Female.*—Length of body 1.9^{mm}, expanse of wings 2.7^{mm}. Antennæ shorter than in ♂ and joints much more closely united; no hairs; flagellum 7-jointed, the club larger in proportion than in the ♂. Abdomen longer than thorax, not pedunculated; ovipositor slightly extruded, light brown in color.

In 1894 Dr. W. H. Ashmead (2) referred this species to the genus Bruchophagus, supposing it to be a parasite of the seed weevils (Bruchidae).

Dr. A. D. Hopkins reared specimens from heads of crimson clover in 1896, at first supposing them to be parasites of the clover-seed midge, since they had been referred to as such in early literature. But upon careful examination of the infested seeds he found that *B. funebris* was feeding on the seeds. Dr. Hopkins (3) wrote as follows:

> Upon close examination to find their host insect, I was thoroughly surprised to find that it was not a parasite of an insect, but that it bred in the seed, and that scarcely a seed could be found in the bag that had not been a host of one of the interesting little creatures.

Dr. Hopkins (4) again mentions this insect:

> Additional evidence obtained from a study of all stages of this insect, together with some observations on its habits, seems to leave no doubt that this interesting little Chalcidid is a destructive enemy of the seed of crimson and common red clover. I also determined that it passes the winter in the seed left in the open field, evidently in the larval stage.

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[1] Figures in parentheses refer to "Literature cited," p. 20.

DISTRIBUTION.

In 1904 Dr. E. G. Titus (5) gave the following distribution of *B. funebris* by States: Hanford, Cal.; Fort Collins, Colo.; Marengo and Urbana, Ill.; Winona Lake, Ind.; Richmond, Kans.; Agricultural College, Mich.; Agricultural College, Miss.; St. Anthony Park, Minn.; Quaker Street, N. Y.; Corvallis, Oreg.; Providence, R. I.; Burlington, Vt.; Pullman, Wash.; Danville and Virginia Beach, Va., and the District of Columbia. Mr. George I. Reeves reported this species from Lincoln, Nebr., the same year, and in 1915 Prof. F. M. Webster reported its presence at Tyngsboro, Mass., Kensington, Md., Lebanon, N. H., and Chambersburg, Pa. It was further reported from Wakeman, Ohio, in 1905, by W. B. Hall; at Albuquerque, N. Mex., 1908, Sacaton, Ariz., 1909, and central Utah, 1910, by C. N. Ainslie; at Plano, Tex., in 1909, by T. D. Urbahns; at Twin Falls, Idaho, in 1911, by H. T. Osborn; at Nashville, Tenn., in 1910, by George G. Ainslie; at Newell, S. Dak., in 1913, by C. N. Ainslie; at Alva, Okla., in 1913, by E. G. Kelly; at Charleston, Mo., in 1914, by G. W. Barber; at Minden, Iowa, in 1915, by T. D. Urbahns; at Hagerstown, Md., in 1916, by H. L. Parker; and at Fallon, Nev., in 1917, by T. D. Urbahns.

Under later dates, *B. funebris* was reared from many additional localities by the writer and other persons connected with the Bureau of Entomology, so that at the present time it is known to be present in practically every locality in the United States where either red clover or alfalfa seed is grown to any extent.

In 1913 the writer found it in alfalfa seed reported by a seed dealer to have arrived from Germany. This species has also been reported from other foreign countries as follows:

1906, N. E. Hansen, *Medicago falcata*, Omsk, Siberia.
1907, C. V. Piper, alfalfa, Turkestan, Asia.
1908, Mr. Brand, alfalfa, Pisa and Matilla, Chile.
1908, N. E. Hansen, alfalfa, Tashkent, Turkestan, Asia.
1908, J. G. Sanders, alfalfa, Tashkent, Turkestan, Asia.
1910, C. P. Lounsbury, alfalfa, Cape Town, South Africa.

CHARACTER OF ATTACK.

The injury caused by the chalcis-fly consists entirely of the hollowing out of the developing seeds (Pl. II, fig. 2). By the time the alfalfa seed pods and the clover heads have matured the destructive work of this minute larva has been completed within the infested seed, and the result is a hollow seed containing the insect in one of its stages, or simply the seed shell from which the adult insect has emerged. (Pl. II, figs. 3 and 4.) This pest in no way interferes with the growing of either alfalfa or red clover for forage purposes, except in so far as a very poor stand may be expected when infested and hollowed-out seeds are planted. The loss caused by this pest is to the growing of alfalfa or clover for a seed crop, and the insect may therefore be considered strictly a seed pest.

FOOD PLANTS.

The following plants have been found to be food plants of the chalcis-fly, *B. funebris*, seeds of each of these having been found infested by this species:

Alfalfa (*Medicago sativa*).
Red clover (*Trifolium pratense*).
Bur clover (*Medicago hispida nigra*).
Bur clover (*Medicago hispida terebellum*).
Bur clover (*Medicago hispida denticulata*).
Medicago falcata.
Medicago ruthemia.
Medicago tunetana.
Medicago tuberculata.
Medicago arabica.

The seeds of the following list of closely related plants apparently are not attacked by the chalcis-fly:

White clover (*Trifolium repens*).
Alsike clover (*Trifolium hybridum*).
Yellow sweet clover (*Melilotus officinalis*).
White sweet clover (*Melilotus alba*).
Sour clover (*Melilotus indica*).

ECONOMIC IMPORTANCE.

Table I shows the destruction of alfalfa and clover seed as found in samples of seed taken in the given localities.

TABLE I.—*Percentage of alfalfa and red clover seed found infested by Bruchophagus funebris.*

Locality.	Date of collection.	Seeds examined.		Seed destroyed.	Remarks.
		Total.	Infested.		
				Per cent.	
Aberdeen, Idaho	Sept. 19, 1914	886	7	0.7	Alfalfa seed.
Do	do	902	45	5	Do.
Albany, Oreg	Sept. 5, 1914	156	81	52	Red clover seed.
Bard, Calif	May 7, 1915	1,374	723	52.6	Alfalfa seed.
Do	May 12, 1915	1,000	361	36.1	Do.
Do	May 20, 1915	1,100	260	23.6	Do.
Do	May 28, 1915	1,053	222	21	Do.
Do	June 8, 1915	1,236	400	32.3	Do.
Do	June 17, 1915	1,091	291	26.5	Do.
Do	June 23, 1915	1,005	268	26.6	Do.
Do	July 2, 1915	1,115	315	28.2	Do.
Do	do	1,228	311	25.3	Do.
Do	July 28, 1915	1,255	672	54.4	Do.
Do	Aug. 4, 1915	1,364	489	36	Do.
Do	do	1,125	245	21.7	Do.
Do	Aug. 8, 1915	1,028	533	48.1	Do.
Do	do	1,157	330	28	Do.
Do	Oct. 12, 1915	872	747	85	Do.
Bishop, Calif	Nov. 10, 1914	691	212	30.7	Do.
Buckeye, Ariz	Sept. 2, 1912	263	217	82	Do.
Burley, Idaho	Sept. 11, 1914	1,307	50	3.8	Do.
Caldwell, Idaho	Sept. 10, 1914	866	237	27.3	Do.
Chico, Calif	Apr. 12, 1912	3,007	1,761	58.5	Do.
Do	Oct. 25, 1914	263	83	31	Do.
Chino, Calif	Sept. 24, 1912	574	195	34	Do.

TABLE I.—*Percentage of alfalfa and red clover seed found infested by Bruchophagus funebris*—Continued.

Locality.	Date of collection.	Seeds examined.		Seed destroyed.	Remarks.
		Total.	Infested.		
				Per cent.	
Columbus, Ohio	Oct. 17, 1908	559	50	8.9	Red clover.[1]
Corcoran, Calif	Oct. 3, 1912	317	118	37	Alfalfa seed.
Dos Palos, Calif	Sept. 15, 1913	993	264	26.5	Do.
Glendale, Calif	Aug. 26, 1912	311	32	12	Do.
Do	Jan. 12, 1914	603	145	24	Do.
Gunnison, Utah	Sept. 23, 1914	816	34	4	Do.
Do	do	876	105	12	Do.
Do	do	835	59	7	Do.
Do	do	297	11	3.7	Do.
Do	do	591	35	5.9	Do.
Logan, Utah	Dec. 28, 1915	1,527	680	44.5	Do.[2]
Manti, Utah	Sept. 23, 1914	1,097	92	8.4	Do.
Mesilla Park, N. Mex	Aug. 30, 1908	561	130	30.5	Do.[3]
Do	do	531	170	47.1	Do.
Murrietta, Calif	Aug. 7, 1915	1,140	177	15.6	Do.
Myton, Utah	Apr. 5, 1912	1,000	395	39.5	Do.[4]
Nephi, Utah	Sept. 24, 1914	994	35	3.5	Do.
Do	do	845	119	13.5	Do.
Do	do	700	131	18.5	Do.
Do	do	1,046	19	1.8	Do.
Do	do	935	23	2.4	Do.
Pendleton, Oreg	Sept. 9, 1914	764	229	30	Do.
Red Bluff, Calif	Sept. 3, 1914	966	147	15.2	Do.
Riverside, Calif		492	109	22	Do.
St. Anthony, Idaho	Sept. 17, 1914	629	23	3.6	Do.
Salt Lake City, Utah	May —, 1910	100	37	37	Do.[3]
Do	do	400	149	62.8	Do.[3]
Do	do	500	186	37.2	Do.[3]
Do	Oct. 17, 1910	500	286	57	Do.[3]
Do	Nov. 22, 1910	107	77	72	Do.[3]
Do	Sept. 20, 1911	450	5	1	Clover.[4]
Do	Jan. 16, 1914	1,387	52	3.7	Alfalfa seed.
Somerton, Ariz	May 10, 1915	1,235	664	53.8	Do.
Tempe, Ariz	June 28, 1912	167			Do.[5]
Do	July 1, 1912	348			Do.[5]
Do	July 8, 1912	670	237	35.4	Do.
Do	July 15, 1912	684	403	50	Do.
Do	Aug. 10, 1912	301	235	78	Do.
Do	Oct. 29, 1912	321	134	42	Do.
Do	July 22, 1913	899	412	46	Do.
Do	do	2,270	778	35	Do.
Do	Aug. 20, 1913	939	439	47	Do.
Do	July 24, 1914	1,445	408	28	Do.
Do	Aug. 15, 1914	1,185	212	18	Do.
Twin Falls, Idaho	Sept. 14, 1914	1,117	322	29	Do.
Tulare, Calif	Oct. 1, 1912	600	154	25.5	Do.
Do	Nov. 18, 1913	655	243	37.5	Do.
Washington, D. C	Oct. 20, 1910	361	96	26	Clover.[1]
Wellington, Kans	June 3, 1910	400	333	83	Alfalfa seed.[6]
Do	June 6, 1910	600	480	80	Do.
Woodland, Calif	Sept. 2, 1914	558	98	18.	Do.
Yuma, Ariz	Aug. 6, 1913	1,143	109	9.5	Do.
Do	Aug. 7, 1913	833	277	24.4	Do.
Do	do	2,174	524	24	Do.
Do	Oct. —, 1913	915	646	72.5	Do.
Do	Dec. 19, 1913	484	443	91	Do.
Do	Dec. 22, 1913	1,377	1,017	74	Do.
Do	June 18, 1914	335	76	22.7	Do.
Do	do	1,076	171	16	Do.
Do	do	391	82	21	Do.
Do	do	585	24	4.2	Do.
Do	do	554	95	17	Do.
Do	Apr. 24, 1915	706	277	39.2	Do.
Do	June 11, 1915	1,047	311	29.5	Do.
Do	July 21, 1915	1,295	214	16.5	Do.
Do	do	1,106	211	19.1	Do.

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[1] Note made by T. H. Parks.
[2] Note made by E. L. Barrett.
[3] Note made by C. N. Ainslie.
[4] Note made by H. T. Osborn.
[5] Note made by R. N. Wilson.
[6] Note made by E. G. Kelly.

The loss to the alfalfa-seed crop depends upon the total yield and upon the percentage of infestation.

This loss frequently varies from 50 to 400 pounds per acre as a result of the destructive work of this pest. At an average price of 12 cents per pound the loss may then be estimated at from $6 to $48 per acre annually. While this loss in the aggregate is enormous, there is frequently an additional loss which is caused by the planting of uncleaned seed, resulting in a poor stand and the loss of time and money in replanting.

COMMON NAMES.

Bruchophagus funebris is commonly known throughout the Eastern States as the clover-seed chalcis-fly. Throughout the alfalfa seed-growing districts, which are located almost entirely in the Western States, this insect is better known as the alfalfa-seed chalcis fly. Many farmers, however, frequently refer to its destructive work as that of a seed weevil, while others simply refer to the injured seed as "blighted seed," and apparently are not familiar with the cause of this condition.

MEANS OF DISPERSION.

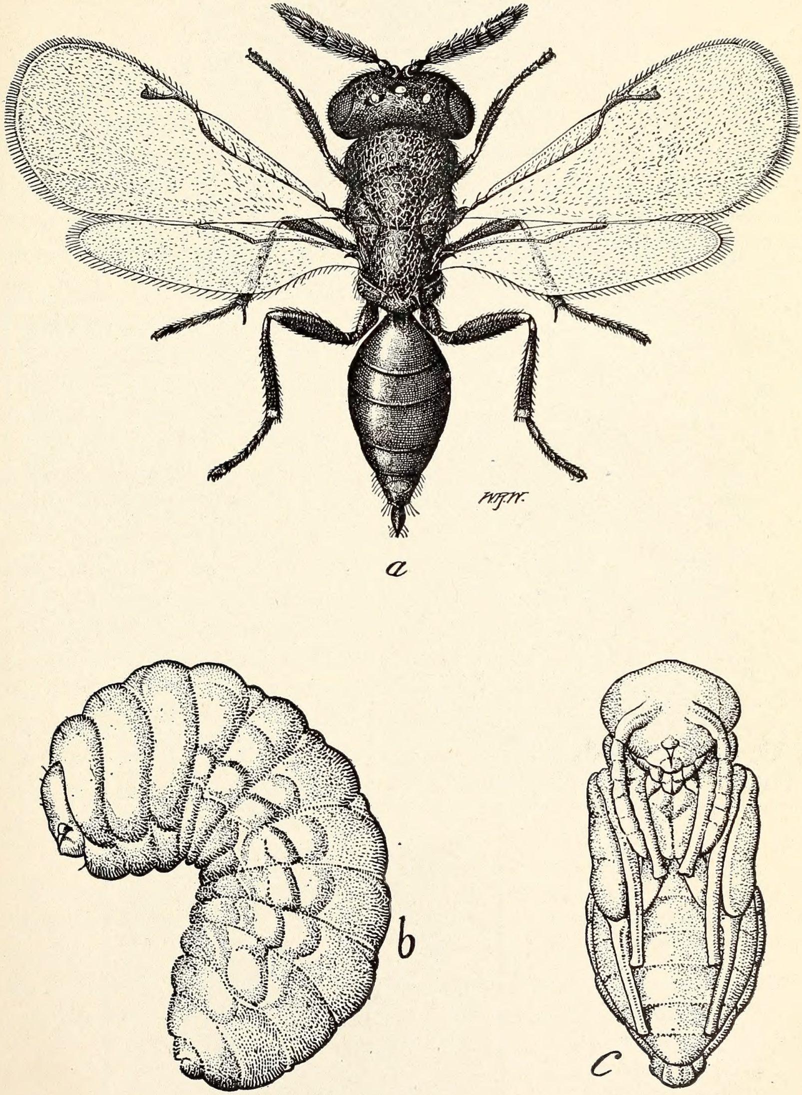
At the present time it is impossible to study in detail the means by which *B. funebris* became distributed over the different parts of the United States, for the reason that it is now found in almost every locality where either alfalfa or red-clover seeds are grown to any extent. It is, in fact, very probable that this species is a native of this country.

The shipment of infested seed from one locality to another has, without doubt, been a great factor in the dispersion of the alfalfa-seed chalcis-fly, since one can visit seed houses and frequently find hundreds of the adults present in the sacks of either clover or alfalfa seed.

Their spread probably was greatly aided also by the early settlers, who traveled across the country with horses and wagons, taking with them either clover or alfalfa hay bearing a few infested seed pods.

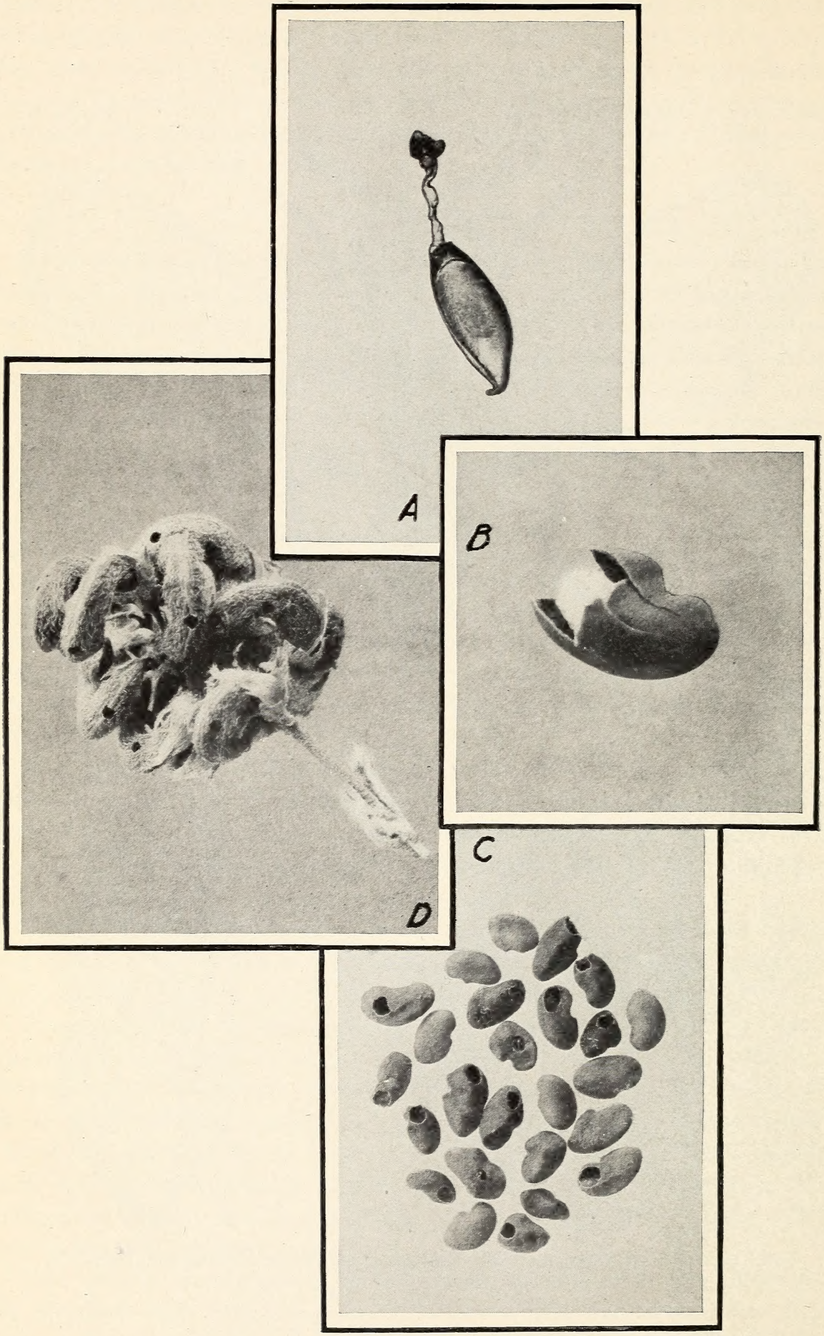
Throughout the mountain States there frequently is found a chain of small alfalfa patches along the mountain streams connecting the larger irrigation valleys, where alfalfa plants, along the edges of these fields, develop seed pods, and render conditions favorable for the spread of this insect from one field to another. Infested seeds and pods are undoubtedly washed down the mountain streams, enter irrigation canals, and may become distributed with the water over new fields many miles away.

The wind is an important factor in the dispersion of the adults of *B. funebris* over adjoining fields. The writer has frequently observed large numbers of chalcis-flies being carried by the strong summer breeze from one field to another. On one occasion more than



THE CLOVER AND ALFALFA SEED CHALCIS-FLY (BRUCHOPHAGUS FUNEBRIS).

a, Adult; *b*, larva; *c*, pupa.



THE CLOVER AND ALFALFA SEED CHALCIS-FLY.

A, Egg; B, larva in hollow seed; C, cluster of seed pods showing openings from which adults emerged; D, seeds hollowed by *Bruchophagus funebris*.

two hundred adults of *B. funebris*, carried by the wind from a near-by field, alighted upon the writer's shirt in the course of a few minutes. Further observations revealed thousands of these chalcis-flies being carried by the winds.

LIFE HISTORY.

METHOD OF STUDY.

The life history of this seed chalcis-fly was studied by selecting old alfalfa plants and first carefully removing all seed pods which had begun to develop. The fresh blossoms were then artificially pollenized and covered with thin cheesecloth bags. About one week later the bags were removed and a mica breeding cage was placed over the soft green seed pods. One or more adults of *B. funebris* were then placed in the cage for oviposition into the green seeds. The mica cage, with the adults of *B. funebris*, was usually removed after one day, and the seed pods were again covered with cheesecloth bags. Here they were allowed to remain until desired for dissection and study of the various stages of the chalcis-fly, or until the first adults emerged. It was found that larvæ of *B. funebris*, which had been removed from their natural cavities in the infested seed, could be transferred to a cavity made in a small cork, and if properly covered with a medical capsule, or a small glass vial, they could be reared to the adult stage without difficulty in the laboratory. The hibernating larvæ and pupæ also were carried successfully through to the adult stage in cavities made between two layers of sheet cork.

Examinations of matured seeds were made by soaking the seeds for a few hours and then dissecting them under a binocular microscope.

The period of incubation was studied by allowing adults to oviposit into seed pods covered with mica cages and then dissecting some of the seed from day to day until the first eggs were found to have hatched.

THE EGG.

The egg (Pl. II, A) of *B. funebris* is small, elongated, measuring about 0.2 mm. long and 0.08 mm. in thickness. It consists of a delicate membranous bag filled with a semiliquid substance. One end of the egg is terminated in a flexible point, while the opposite end is marked by a slender tube-like film measuring about 0.2 mm. in length.

LARVA.

The larva (Pl. I, B) is grublike in shape. It averages 1.9 mm. long and 0.9 mm. wide when fully developed. The pointed brown mandibles are chitinous and visible to the unaided eye. With the exception of the mandibles the larva is white. It has no feet or legs and is almost free from pubescence. The 13 body segments are at times quite prominent.

PUPA.

The pupa (Pl. I, C) measures 1.8 mm. long. It is at first white, later the eyes and ocelli are brown, and before becoming adult the pupa turns black. All appendages are folded close to the body, and a thin pupal skin covers the insect in this stage of its development.

ADULT.

The adult (Pl. I, A) of *B. funebris* is a very small black insect measuring about 2 mm. in length. Frequently thousands are seen flying over the horses and mower when the alfalfa seed crop is being harvested. They also collect in great swarms on the shady sides of alfalfa seed stacks, from which these insects emerge. Farmers frequently mistake the adults of this species for gnats, which are about the same size and are frequently very troublesome at the time when the chalcis-fly is most abundant.

SEASONAL HISTORY.

EARLY DEVELOPMENT.

The first development of the chalcis-fly may be found in February and March throughout the Southwest, when the hibernating larvæ begin to transform to the pupal stage. Spring temperatures and moisture conditions determine the time of this transformation. In colder climates it is much later, and under desert conditions the larval stage may be prolonged indefinitely.

FIRST APPEARANCE OF ADULTS.

The first adults appear in the spring, about four or five weeks after warm weather has set in. It is probable that in southern California adults may be active in small numbers throughout the entire winter. Adults of *B. funebris* were taken in the fields in the San Fernando Valley, Calif., as early as March 3, but they usually do not appear in large numbers until about April. At Yuma, Ariz., they make their appearance in March, and the first seed pods, which usually develop along the check ridges, become infested by the middle of April. On April 17 green pods were taken at the edge of a field at Yuma, and upon careful examination, 8 seeds showed very small larvæ, 5 showed half-grown larvæ, 15 showed full-grown larvæ, and 20 showed *B. funebris* pupæ. E. G. Kelly observed adults of *B. funebris* in the field at Wellington, Kans., as early as April 21. H. T. Osborn reared them in out-of-door breeding cages in the same locality as early as April 17. In the valleys of central California the adults of *B. funebris* become active in April and oviposit into the seed pods of bur clover (*Medicago hispida*), which forms seed pods much earlier than alfalfa.

Mr. Kelly reported adults of *B. funebris* active and ovipositing in alfalfa seed pods at Wellington, Kans., by June 10, 1911.

OVIPOSITION.

The adults of *Bruchophagus funebris* appearing in early spring are not always able to locate developing seeds of their host plants at the time of their emergence, and it may be three or four weeks before an opportunity for oviposition is found. In midsummer oviposition takes place within a few days after the adult emerges. Green and half-grown seed pods are favored for oviposition. The female adult takes a position directly over the slight enlargement on the pod caused by the developing seed. The ovipositor is forced through the green seed pod and into the soft watery seed, where the egg is placed. The time required for oviposition is about one minute.

POSITION OF EGG.

The egg is usually placed just beneath the inner integument of the seed, sometimes between the cotyledons, and frequently within the semiliquid contents of a cotyledon. It is placed singly, although oviposition into the same seed may be repeated. The mark left by oviposition may sometimes be seen in the form of a very minute spot on the surface of the seed, but this is usually not discernible even with the aid of a microscope. The relative position of the seeds in a pod in no way seems to influence the chances of infestation.

EGG STAGE.

Observations made during the month of April at Pasadena, Calif., showed the period of incubation as requiring from 7 to 12 days. In the month of June the incubation period was found to be about five days. E. L. Barrett, assisting the writer, found eggs of *B. funebris* hatching in four days during very warm weather.

LARVAL STAGE.

The larva, upon hatching from the egg, finds itself surrounded with the soft contents of the growing seed. The first feeding takes place after the larva is one or two days old, and in midsummer rapid growth follows. The larva of *B. funebris* never leaves the seed in which it is developing to infest another seed in the same pod. Where two or more larvæ chance to be in the same seed, one or both usually perish before development is completed. Molts, apparently, occur indefinitely in the larval stage, and appear to be the peeling off, in small fragments, of the old larval skin. The time required for the complete development of the larval stage varies under differing temperature conditions, and depends upon the condition of the seed in which it develops. Under the most favorable conditions, as observed by the writer, the larvæ completed development in 12 days. In early spring this period was prolonged to 30 days.

PERIOD OF AESTIVATION.

The factors of greatest influence in the life cycle of *B. funebris* are those which determine the period of aestivation. Larvæ of this species, reaching their full larval development in soft green seeds, at once transform to the pupal stage and soon emerge as adults. On the other hand, if the infested seeds mature and harden before the larval development is fully completed aestivation follows. This resting period frequently continues throughout the remainder of the season, or until conditions become favorable for pupation and transformation to the adult stage.

Atmospheric humidity, temperature, and irrigation are important factors determining the duration of aestivation. Aestivation occurs frequently in the larvæ of *B. funebris* during the months of July, August, and September. Favorable conditions may at any time cause transformation to the pupal stage or aestivation may continue into hibernation. The transformation usually occurs at any time between March and July of the following season, though in exceptional cases the larval stage may be continued into the second year.

Alfalfa seeds collected in the fields on September 24, 1912, and kept dry in the laboratory showed adults of *B. funebris* emerging throughout the season of 1913 and larvæ living in the seeds until the spring of 1914. The last adults of *B. funebris* emerged as late as September, 1914. This habit causes great diffusion in the adults of the species. It was found that some of the progeny of a single adult developed and reached maturity in about 30 days, while other progeny from the same adult and from eggs deposited on the same day did not mature until the next year.

PUPATION.

The period of pupation in early spring requires an average of about 30 days, as shown by Table II. As the season advances and the days become warmer the duration of the pupal period is much shortened. Pupæ developing in midsummer have a pupal period of from 6 to 10 days, and under the most favorable conditions this period is without doubt shorter than that observed in the breeding cages.

LATE APPEARANCE OF ADULTS.

While some of the larvæ apparently go into hibernation as early as August, adults may be seen emerging from the infested seeds and seed pods in the months of October and November.

At Glendale, Calif., adults were still active in the fields as late as November 18, in 1912. C. N. Ainslie reported *B. funebris* as being numerous among the florets of red clover on September 17, in 1913, at Fairmont, Minn. At Albany, Oreg., the writer found them active over red clover on September 15, in 1914. At Nephi, Utah, they were active on alfalfa florets on September 24 of the same year. Activity of the adults, oviposition, and development of larvæ usually continue as long as green seed pods are present in the fields. The first heavy frost kills the adults and pupæ and most of the undeveloped larvæ.

The writer's observations show that in southwestern Arizona this species may have as many as four generations in a single season. This is, of course, under favorable conditions—first on volunteer alfalfa and then in the irrigated seed fields. Without doubt it completes at least two generations in most of the intermountain seed-growing districts, where the growing seasons are frequently very short. The minimum number of generations in a single season may be less than one under very unfavorable conditions, as it required more than one season for some of the individuals under observation to reach the adult stage.

TABLE II.—*Length of the pupal period for 50 individuals of Bruchophagus funebris which hibernated in the larval stage.*

Pupal period of male.	Days.	Pupal period of female.	Days.
Mar. 10 to Apr. 14	35	Mar. 10 to Apr. 22	43
Mar. 11 to Apr. 22	42	Mar. 10 to Apr. 14	35
Mar. 10 to Apr. 21	42	Mar. 11 to Apr. 14	34
Feb. 19 to Apr. 12	52	Mar. 10 to Apr. 22	43
Mar. 10 to Apr. 22	33	Mar. 11 to Apr. 22	42
Mar. 14 to Apr. 6	23	Mar. 11 to Apr. 21	41
Mar. 17 to Apr. 16	30	Mar. 20 to Apr. 28	39
Mar. 11 to Apr. 2	22	Mar. 11 to Apr. 14	34
Mar. 11 to Apr. 4	24	Mar. 21 to Apr. 24	34
Mar. 14 to Apr. 6	23	Mar. 10 to Apr. 14	35
Mar. 14 to Apr. 10	27	Mar. 17 to Apr. 22	36
Mar. 14 to Apr. 11	28	Mar. 10 to Apr. 14	35
Mar. 23 to Apr. 25	23	Mar. 10 to Apr. 14	35
Mar. 18 to Apr. 19	32	Mar. 10 to Apr. 22	43
Mar. 11 to Apr. 1	21	Mar. 14 to Apr. 13	30
Mar. 11 to Apr. 4	24	Mar. 16 to Apr. 13	28
Mar. 11 to Apr. 4	24	Mar. 18 to Apr. 18	31
Mar. 16 to Apr. 13	28	Mar. 18 to Apr. 19	32
Mar. 14 to Apr. 4	21	Mar. 12 to Apr. 21	40
Mar. 17 to Apr. 15	29	Mar. 11 to Apr. 6	26
Mar. 13 to Apr. 10	28	Mar. 14 to Apr. 11	28
Mar. 18 to Apr. 14	27	Mar. 14 to Apr. 15	32
Mar. 11 to Apr. 2	22	Mar. 14 to Apr. 11	28
Mar. 11 to Apr. 6	26	Mar. 13 to Apr. 15	33
Mar. 11 to Apr. 2	22	Mar. 11 to Apr. 6	26
Average	28.3	Average	34.5

HIBERNATION.

B. funebris hibernates in the larval stage within the infested seed, and the first larvæ enter hibernation as early as August. In fact, many larvæ, after spending a part of the summer in aestivating, continue into hibernation without resuming apparent activity. On the other hand, large numbers of larvæ of this species can be found active in the seeds throughout September and October, and a few of them have been found feeding in the green alfalfa seeds throughout the month of December and even until they were killed by heavy frosts in early January. Early spring rains, together with warm days, mark the end of hibernation for a large percentage of the larvæ.

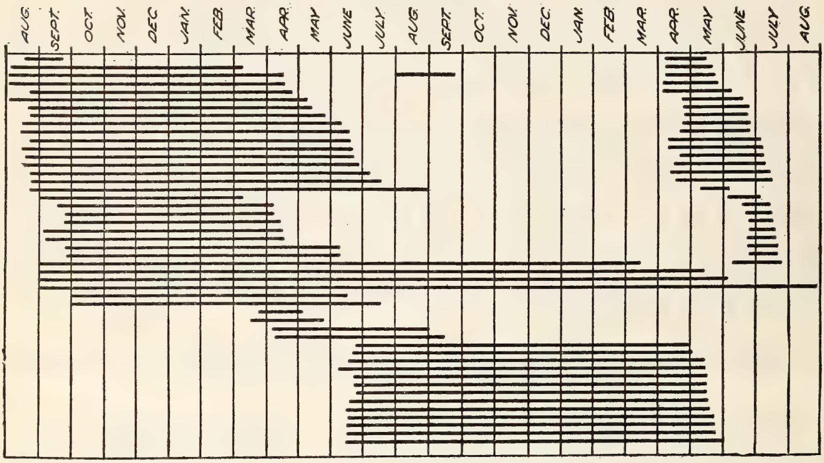


FIG. 1.—Diagram showing development of *Bruchophagus funebris*. Each heavy line shows the time required for one individual from the egg to the adult stage.

In southern California the first pupæ may be found in the latter part of February, and these increase in great numbers throughout the month of March. H. T. Osborn, formerly of the Bureau of Entomology, reported *B. funebris* entering the pupal stage at Wellington, Kans., during the month of March under conditions slightly unfavorable to pupation. Some of the individuals continue to rest in the larval stage until late in the spring, and frequently until midsummer. The greatest number of hibernating larvæ are found along the edges of the field, along fence lines, and in neglected seed fields. In fact, they may be found wherever large numbers of infested seeds have been allowed to remain on the fields unharvested.

In figure 1 each heavy line shows the time required for the development of a single individual of *B. funebris*. The different lengths of these lines show the period of development from the egg to the adult stage to be from 26 days to 24 months, and, in a few cases, to carry the individuals through two winters before the adult stage is reached.

RELATIVE INFESTATION THROUGHOUT THE SEASON.

During the season of 1915 newly formed alfalfa seed pods were taken at Bard, Calif., at intervals of about one week, and examined for infestation by the seed chalcis-fly. It was found that the seed pods taken as early as April 24 showed 39 per cent of the seeds to be infested. On May 8, as many as 52 per cent showed infestation by the chalcis-fly. This was undoubtedly due to the increased emergence of the chalcis-fly. The period from the middle of May to the middle of July, at which time the pods were forming in great abundance, showed the infestation dropping to an average of 28 per cent.

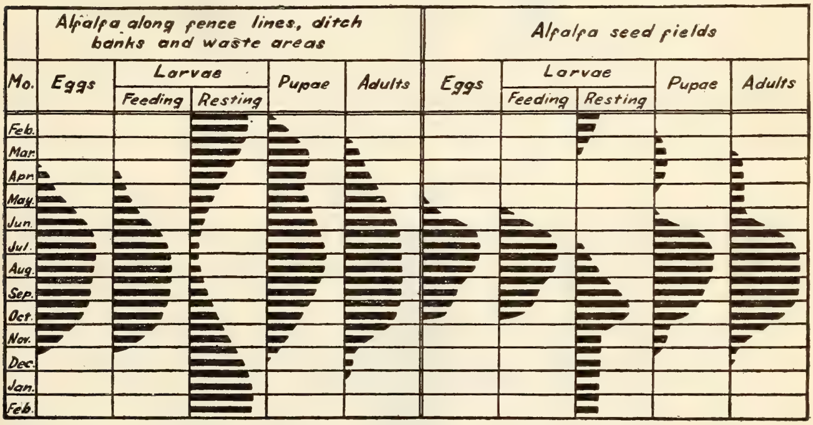


FIG. 2.—Diagram showing comparative abundance of the stages of *Bruchophagus funebris* during the different months of the year.

The average infestation for the period from the middle of July to the end of September increased to 49.5 per cent. This was undoubtedly due to the increased number of the chalcis-flies and to the rapid decrease in the seed pods caused by the cutting of alfalfa on many of the seed fields.

By October all the seed fields had been harvested, and the chalcis-flies were forced to breed in the green pods still forming along the edges of the fields. Seed pods collected on October 12 showed 85 per cent of the seeds to be infested.

Figure 2 shows the comparative abundance of the stages of *B. funebris* during the different months of the year.

It will be noted by the chart that eggs of *B. funebris* are found earlier along fence lines than in the seed field. This is due to the fact that isolated plants on waste areas form the earliest pods, and the seed fields are cut for hay before the seed crop is grown. A sudden scarcity of eggs, feeding larvæ, and pupæ is seen in the field in October, which is due to the harvesting of the latest seed crops. Resting larvæ continue to remain on the field throughout the winter in remaining seed pods, but are much more abundant along fence lines. Spring irrigation of seed fields hastens emergence of adults, and this results in the absence of resting larvæ and pupæ on most fields during the month of May.

PARTHENOGENESIS.

The parthenogenetic habit is well established in the females of this species. Female adults, reared from pupæ which were completely isolated, were placed in cages for oviposition into green alfalfa seed pods. All precautions were taken against earlier infestation of the green seeds. These virgin females oviposited freely, and their progeny was reared in breeding cages. The largest number of offspring from a single female observed by the writer was 20, and all of the progeny of these virgin females proved to be males.

CONTROL METHODS.

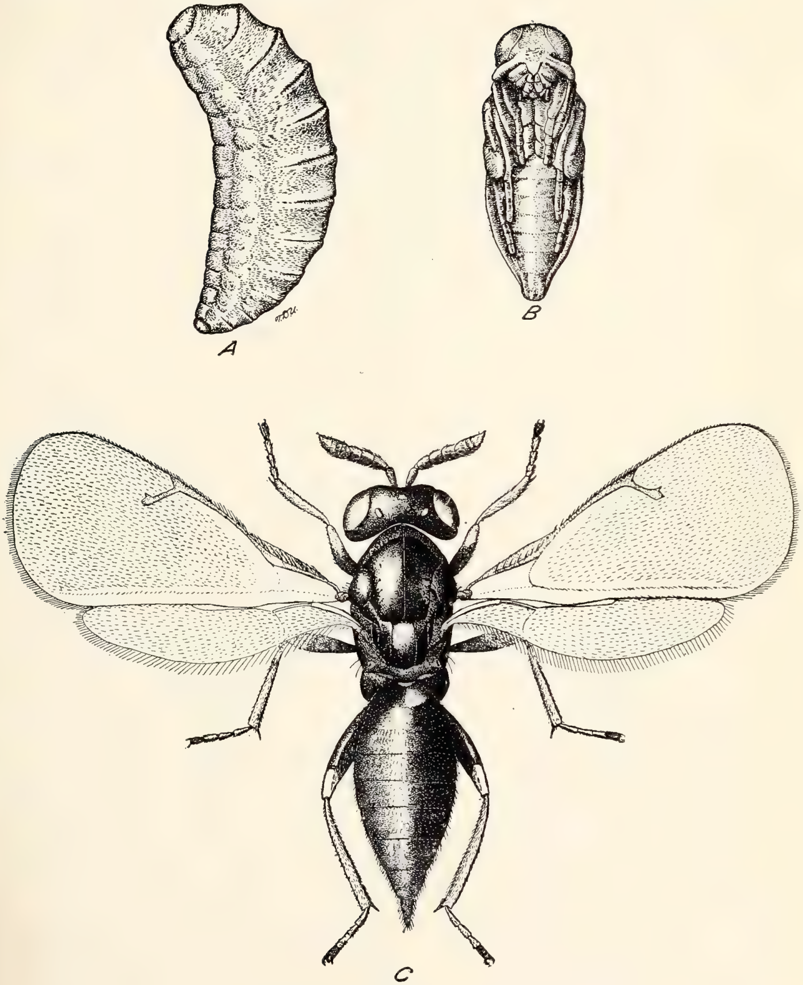
The practical methods of controlling the chalcis-fly in the alfalfa and clover seed fields are mostly cultural methods. It can not be hoped to eradicate this pest from any seed-producing locality; but with the proper methods effectively applied thousands of dollars can be saved annually to the different seed-growing districts. Because of the rapid dispersion of the adults of this species it is of vital importance that control methods should be taken up by community action rather than by the individual.

BURNING OVER OF FENCE LINES.

Everywhere in the alfalfa and red clover seed-growing districts one will find large quantities of standing plants along the fence lines and waste areas bearing the seeds infested by hibernating larvæ. Many hibernating larvæ of the chalcis-fly can be destroyed in the fall of the year by burning over such areas, thereby greatly lessening the abundant emergence of adults in early spring. It has been found that live stock can not be depended upon to rid the fence lines of standing alfalfa in the winter unless there is a great shortage of forage.

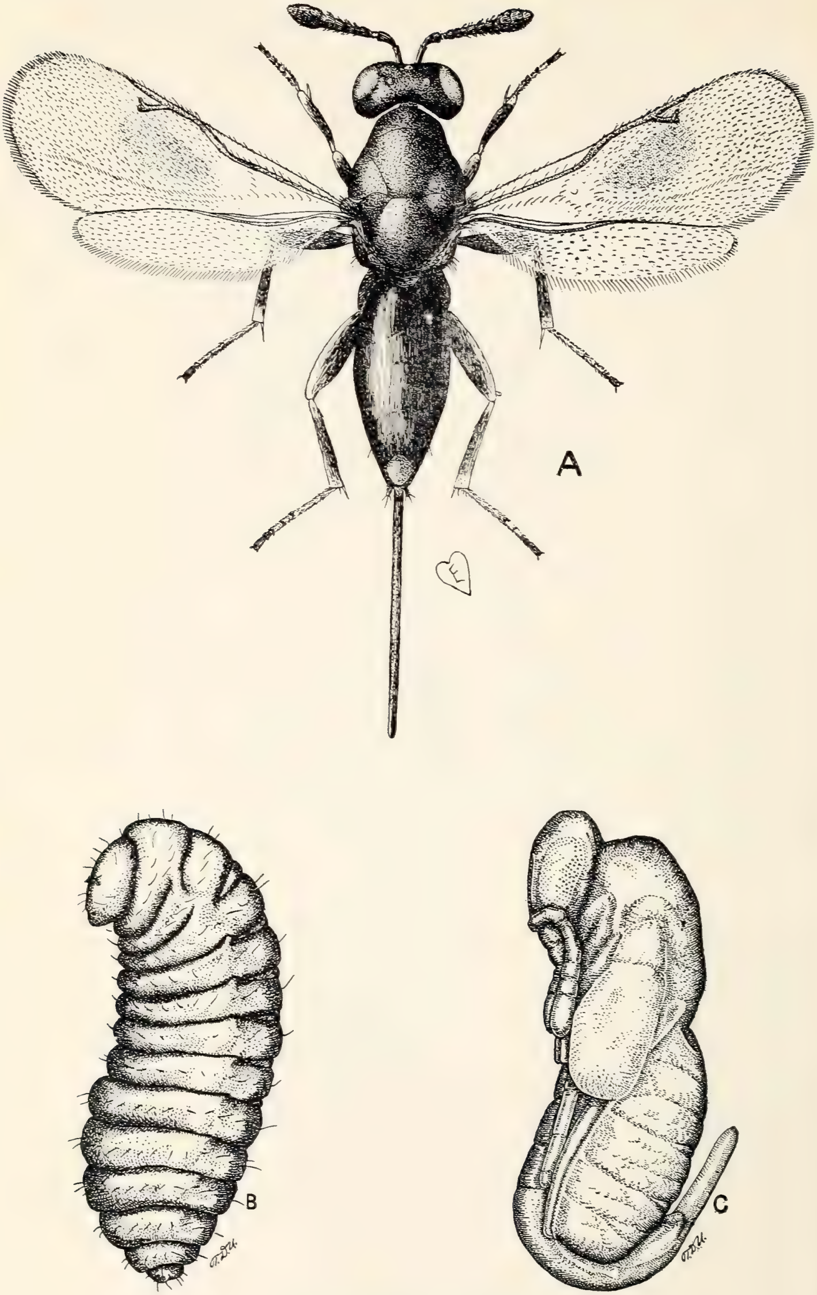
WINTER CULTIVATION.

The cultivation of alfalfa seed fields during the winter is of much value in covering the infested alfalfa seeds containing hibernating larvæ. It is not necessary that infested seeds should be covered to



TETRASTICHUS BRUCHOPHAGI.

A, Larva; B, pupa; C, adult.



LIODONTOMERUS SECUNDUS.

A, Adult female; B, larva; C, pupa.

such a depth that the emerging adults are unable to reach the surface, because the slightest covering of moist soil will cause many of the infested seeds to mold, and prevent development of the pupal or adult stages.

The necessary cultivation can be accomplished by the use of an alfalfa cultivator, spring-tooth harrow, or a disk. Care should be taken that the surface of the field is left smooth, to facilitate close cutting, as well as to prevent clods and gravel from being taken up with the seed when the seed crop is harvested.

IRRIGATION OF ALFALFA SEED FIELDS.

Whenever possible, the alfalfa seed grower should do most of his irrigating in early spring, or before the seed crop is grown. Where this can be practiced, two important points may be gained. First, the tender, rank growth of alfalfa usually following irrigation will be removed as an early fodder crop, and a steady growth of more substantial stems will take its place to produce the seed crop. Second, irrigation of a seed field stimulates the emergence of the chalcis-flies which remain within the infested seeds upon the ground. The humidity of the atmosphere over an irrigated field accelerates the emergence of this pest from seeds of the newly forming crop, which would otherwise become sufficiently dry to force many of the larvæ into a resting period.

It has been supposed by farmers that flooding the seed fields after the first crop of alfalfa has been removed would destroy the larvæ of the chalcis-fly present in alfalfa seeds upon the ground. The writer has found that soaking infested seed in water for four or five days is not sufficient to kill the larvæ resting within the seeds. This would render any attempt at their destruction by irrigation impractical.

CUTTING EARLY PLANTS ON WASTE AREAS.

The fence lines, ditch banks, and other waste areas where volunteer alfalfa can be found, are among the great sources of infestation. It has been found that the chalcis-fly frequently passes through one or two generations on this volunteer alfalfa before the seed fields are advanced to the point where infestation takes place. Every farmer, therefore, in an alfalfa seed-growing district should cut all of the standing alfalfa along the fences and waste areas at the time a hay crop is cut before he grows a seed crop. Alfalfa seed pods should not be allowed to develop anywhere around the field until the plants of the regular seed crop have begun to form pods.

CAREFUL CUTTING OF HAY CROPS.

It is of the greatest importance that special care should be exercised in cutting alfalfa or red clover before the seed crop is grown.

Any plants carelessly cut, so that some stems remain standing, and allowed to develop seed in advance of the regular seed crop, offer favorable conditions for the multiplication of the chalcis-flies. All pocket gophers should be poisoned or trapped and their mounds, as well as other irregularities in the surface of the field, should be leveled so as to make clean cutting possible.

PASTURING BEFORE GROWING SEED.

After removing the first crop of alfalfa for hay, and preparing to grow a seed crop, it is frequently possible to secure a herd of live stock, which may be turned into the field for two or three days. If a sufficient number of horses, cattle, or sheep can be secured they will render a valuable service by destroying the clusters of plants which frequently escape the mower, develop early seed pods, and form favorable breeding places for the development of the chalcis-fly before the regular seed crop has become sufficiently advanced.

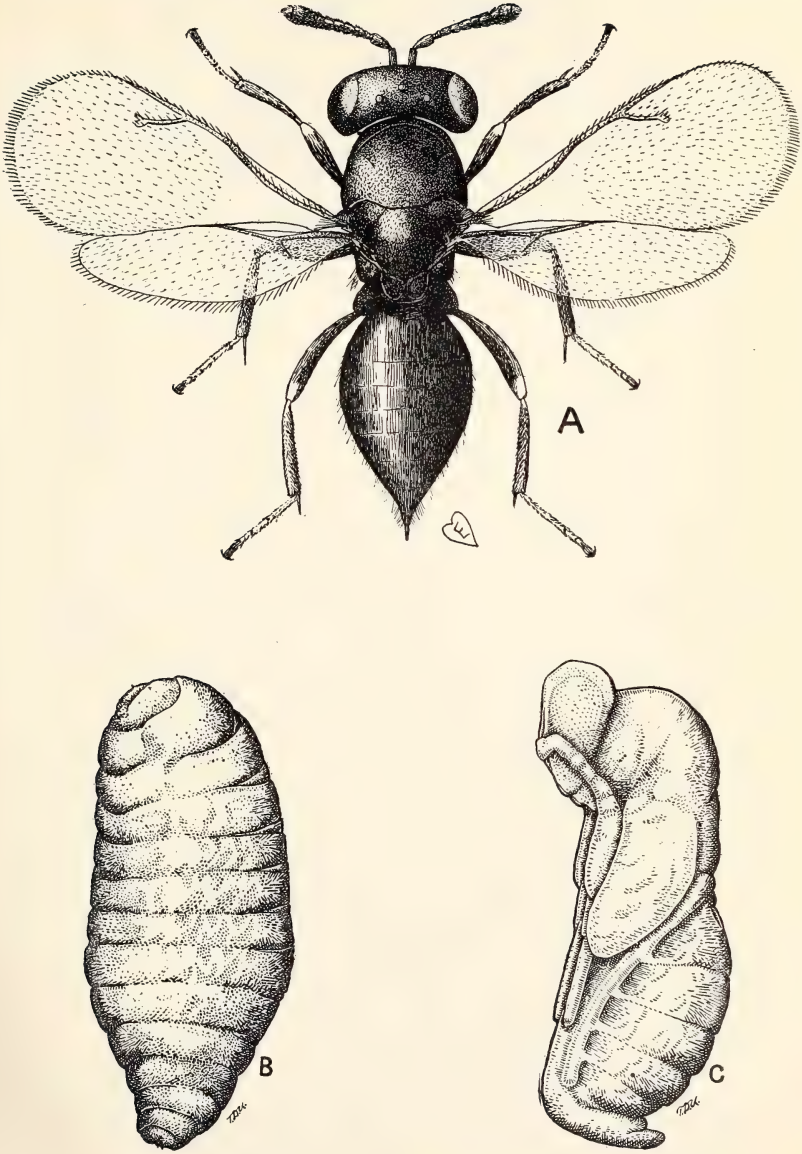
ALLOWING THE SEED CROP TO STAND TOO LONG.

The development of seed pods in the alfalfa seed fields is to a great extent periodical. That is to say, the first set of pods will have been formed when a new set of blossoms appears, or the first set of pods will be reaching maturity when the second set of pods is soft and green. This condition is most noticeable in fields receiving frequent irrigation. The tendency on the part of the farmer is to allow the seed crop to remain on the field too long, while waiting for a third or even a fourth set of pods to develop. It has frequently been observed that the chalcis-fly passes a complete generation in the earlier pods, and, in much greater numbers, infests the later pods forming on the same plants. Consequently, all seed fields should be handled, as much as possible, so that a heavy setting of pods will be secured with the first bloom and the crop removed from the field as early as possible. This will avoid a greater percentage of infested seeds as well as loss of time and will make room for the growing of subsequent crops for hay.

SECOND CROP OF SEED.

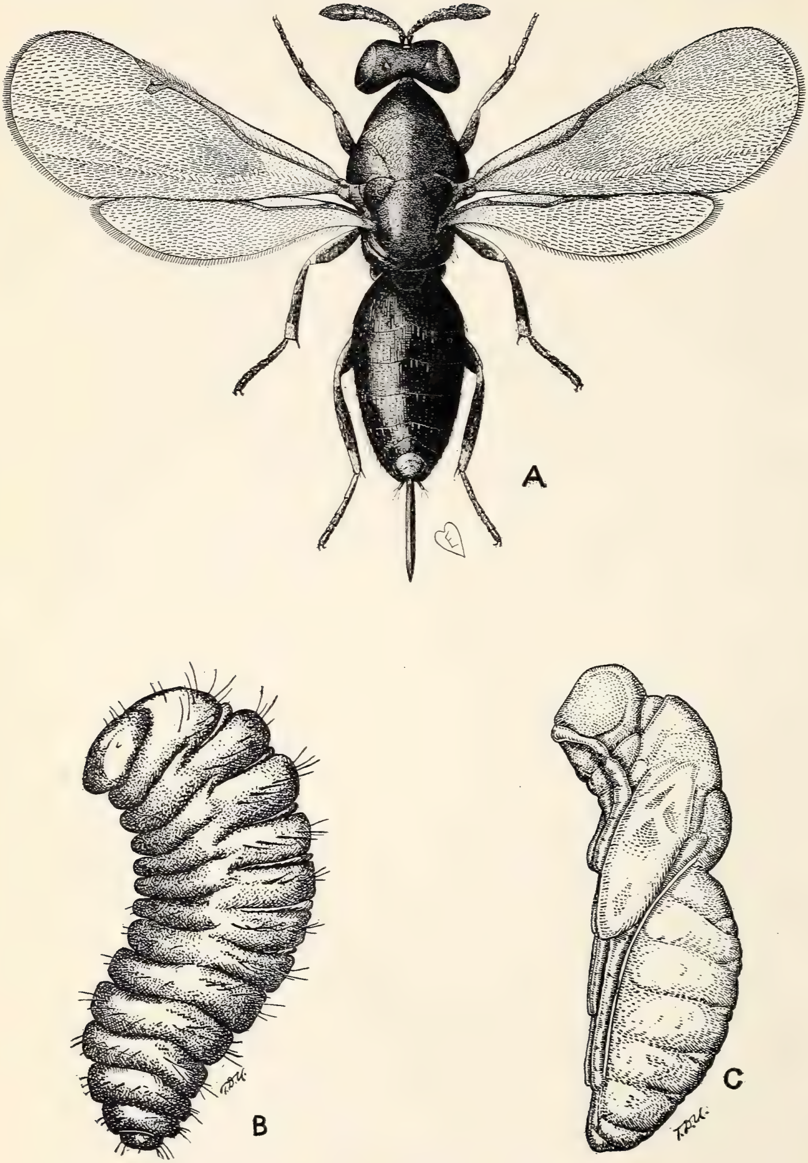
In the Southwest, where there is little danger of early frost, seed growers occasionally attempt to grow two crops of alfalfa seed in a single season. The results of such instances are usually very disappointing, on account of the usual severe infestation common to the second crop. This is frequently so great that the crop does not pay the harvesting expenses.

An attempt to grow a second crop of alfalfa seed in a single season will meet with almost certain failure as a result of the increased abundance of the chalcis-flies late in the summer.



EUTELUS BRUCHOPHAGI.

A ,Adult female; B ,larva; C, pupa.



LIODONTOMERUS PERPLEXUS.

A, Adult female; B, larva; C, pupa.

PASTURING INFESTED FIELDS.

The great mistake of pasturing alfalfa seed fields which have become too severely infested to yield a crop worth harvesting is too frequently made. Live stock walking through the ripe alfalfa cause the seeds to be shelled out and those infested with hibernating larvæ of the chalcis-fly fall on the ground, where they become the source of infestation for the following year.

HYMENOPTEROUS PARASITES.

TETRASTICHUS BRUCHOPHAGI Gahan (6).

Tetrastichus bruchophagi[1] (Pl. III) is generally distributed over most of the northern half of the United States. In the central California alfalfa seed-growing sections it is the most active of the present known parasites of *Bruchophagus funebris.* While it can not be depended upon to control the alfalfa-seed chalcis-fly, it has been observed to destroy about 50 per cent of the larvæ of the chalcis-fly normally in the fields. This species develops within the seed and feeds upon the larval stage of its host.

LIODONTOMERUS SECUNDUS Gahan (8).

Liodontomerus secundus[2] (Pl. IV) has been found by the writer to be an active parasite upon the chalcis-fly when the latter infests the seeds of red clover. It does not seem to attack the chalcis-fly larvæ infesting alfalfa seeds. This species is apparently most active in the red-clover seed-growing sections of Oregon and Idaho. It is active in the fields throughout the summer and hibernates in the larval stage within the infested seeds left on the field.

EUTELUS BRUCHOPHAGI Gahan (8).

Eutelus bruchophagi[2] (Pl. V) is of economic importance as a parasite of the chalcis-fly in the mountain valleys of southern Idaho and central Utah. It has also been found by the writer east of the Sierra Nevada Mountains in northern California. It does not appear to be present in the southwestern alfalfa seed-growing districts.

LIODONTOMERUS PERPLEXUS Gahan (8).

Liodontomerus perplexus[2] (Pl. VI) is a parasite of considerable importance in checking the abundance of the chalcis-fly breeding in alfalfa seeds throughout western Arizona. It was reared as far north as South Dakota by C. N. Ainslie. This parasite attacks the larvæ of its host, and develops within the infested seeds. It has not been observed attacking the chalcis-fly when the latter infested seeds of red clover. This species is most active during midsummer. It appears slower in resuming activity in spring than the other species studied.

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[1] For a more complete account of the species, see Urbahns (10).

[2] For a more complete account of this species, see Urbahns (11).

HABROCYTUS MEDICAGINIS Gahan (7).

Habrocytus medicaginis[1] (Pl. VII) is present throughout California, Idaho, Utah, and parts of Arizona. It has also been reported from South Dakota, Kansas, New Mexico, Nevada, and Oregon. While this parasite can not be depended upon at the present time to control the chalcis-fly in any locality where it has been observed, it is of value in checking the abundant development of its host. This species is parasitic externally upon the larvæ of its host, and completes its development within the infested seed.

From all observations, *Habrocytus medicaginis* attacks the chalcis-fly only when the latter infests the seeds of alfalfa. This parasite has never been found upon the same host within red clover seeds.

TETRASTICHUS VENUSTUS Gahan (7).

Tetrastichus venustus does not occur in sufficient numbers to be considered of economic importance as a parasite of the chalcis-fly in alfalfa seeds. While this species has been reared in small numbers from alfalfa seeds infested with the seed chalcis-fly, and is without doubt a parasite of the latter, the larval stage has not been recognized. Specimens were reared by the writer from Corcoran, Red Bluff, and Tulare, Calif., and from Yuma, Ariz.

TRIMEROMICRUS MACULATUS Gahan (6).[2]

Trimeromicrus maculatus (Pl. VIII) is of economic value as a parasite of the alfalfa-seed chalcis-fly throughout Arizona and California. It has been found especially active in the Buckeye and Yuma Valley seed districts of Arizona, and in the Honey Lake and Imperial Valleys of California.

LIODONTOMERUS INSUETUS Gahan (8).

Notes on file in the Bureau of Entomology, made by H. T. Osborn, under date of September 19, 1910, show the larvæ of this species to be parasitic upon larvæ of *Bruchophagus funebris*. Specimens in the National Museum were reared by C. N. Ainslie, Mesilla

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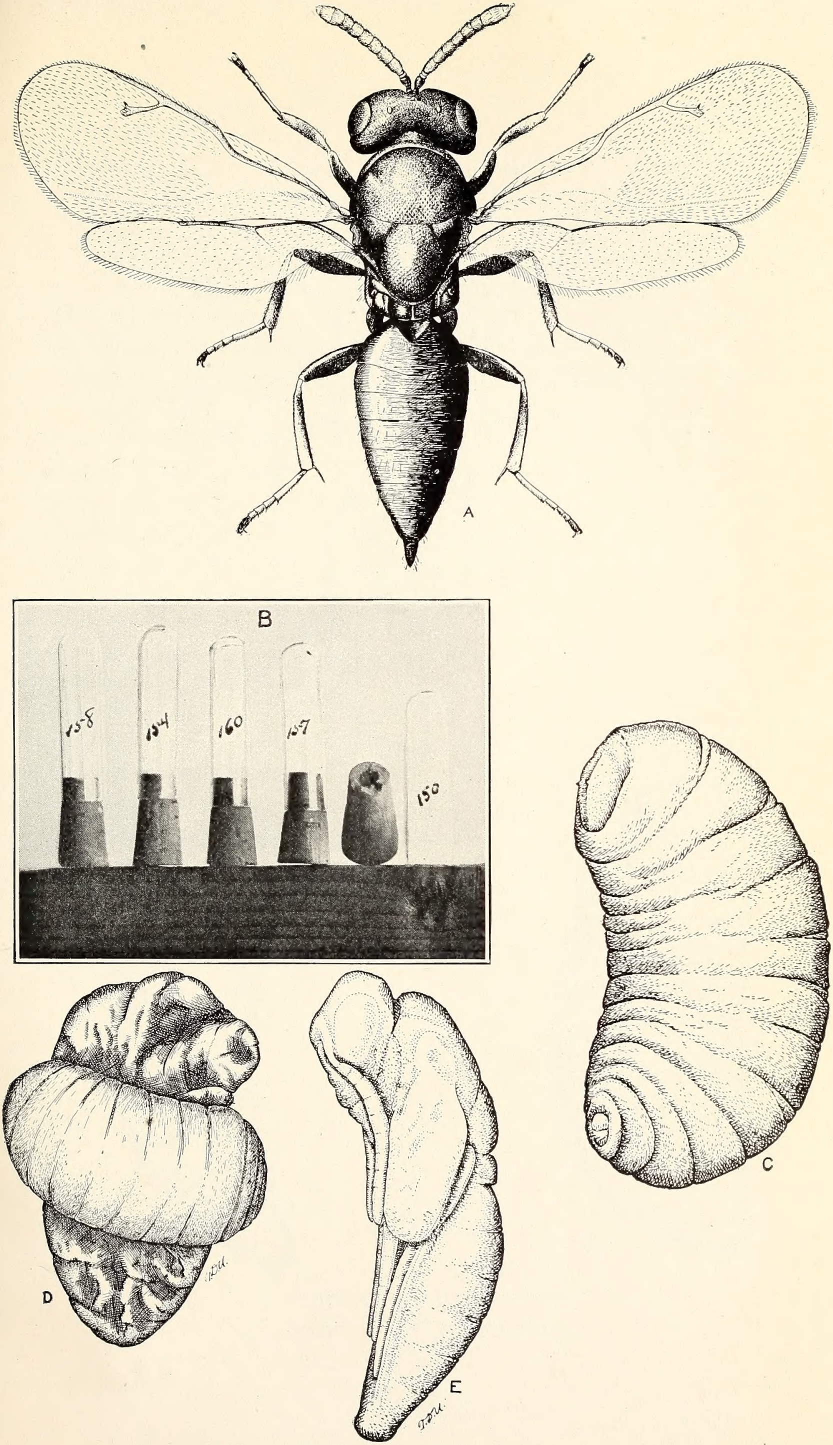
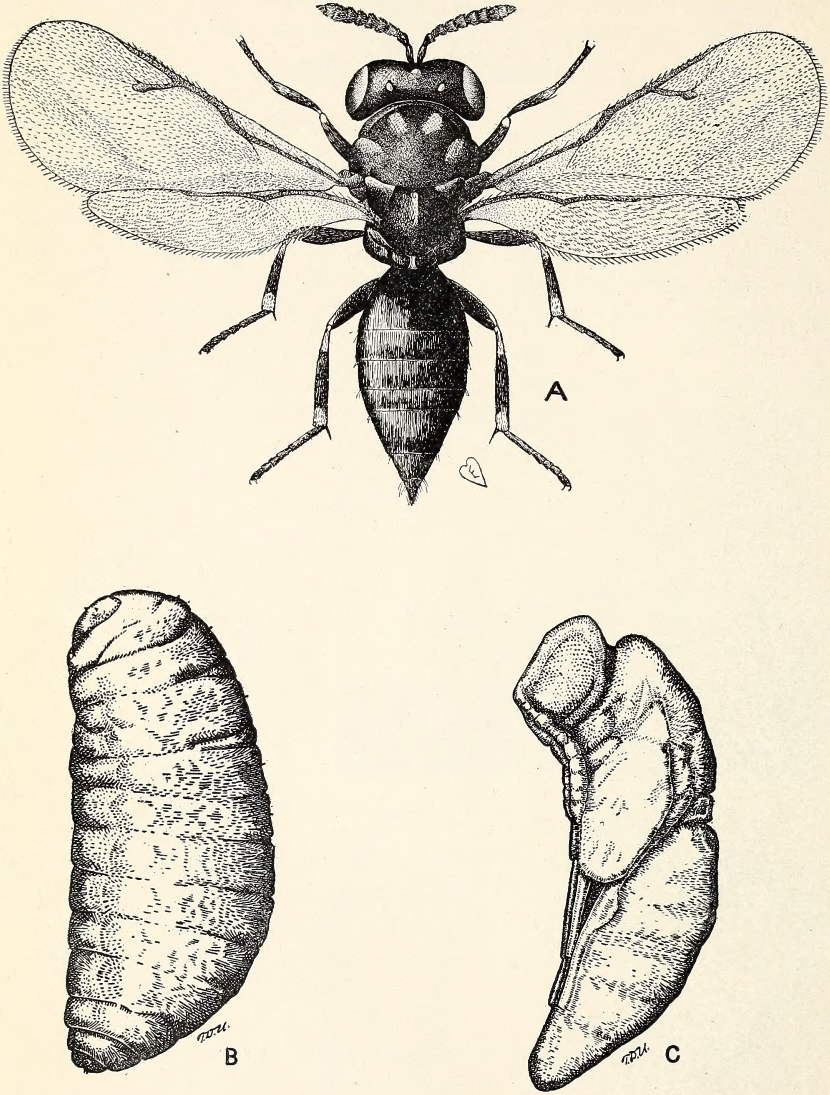
[1] For a more complete account of this species, see Urbahns (9).

[2] For a fuller description, see Urbahns (11).



HABROCYTUS MEDICAGINIS.

A, Adult; B, cages for rearing parasite larvae; C, larva; D, larva destroying its host larva; E, pupa.



TRIMEROMICRUS MACULATUS.

A, Adult female; B, larva; C, pupa.

Park, N. Mex.; H. T. Osborn and E. G. Kelly (1910), Wellington, Kans.; E. G. Smyth and R. N. Wilson, Tempe, Ariz.; and by E. G. Kelly, Sedgwick, Kans. (1914).

The economic importance of this species as a parasite of the chalcis-fly is not known at the present time.

EUPELMUS sp.

A single larva of this species was dissected from an alfalfa seed by M. Marshall, and was found to be parasitic upon the larva of *B. funebris* infesting the seed. The specimen was taken at Pasadena, Calif.

The larva of this species measured about 1.6 mm. in length, and was almost white in color. The head was small and the chitinous mandibles distinctly visible. The body segments were conspicuous and covered with fine pubescence. The larva was rather active.

The pupa, at first white, turned to a smoky-white color, and almost black before the emergence of the adult.

PREDACIOUS MIDGE.

LESTODIPLOSIS sp. Felt.

Larvæ of a midge, described as *Lestodiplosis* sp. by Dr. E. P. Felt, were found in infested alfalfa seeds, where they had apparently destroyed the larva of *B. funebris.* It is quite probable that larvæ of this midge confine themselves to cracked or broken seeds, and where the larva of the chalcis-fly is exposed. The specimens under observation were taken in San Diego County, Calif.

LITERATURE CITED.

(1) Comstock, J. H.
1880. Report of the Entomologist for 1879. *In* Rept. U. S. Commissioner of Agric., p. 185–373.

(2) Ashmead, W. H.
1894. Descriptions of new parasitic Hymenoptera. *In* Trans. Amer. Ent. Soc., v. 21, p. 318–344.

(3) Hopkins, A. D.
1896. Some notes on observations in West Virginia on farm, garden, and fruit insects. *In* Proc. 8th Ann. Meeting of Assn. Econ. Ent. U. S. Dept. Agr., Div. Ent., Bul. 6, n. s., p. 71–74.

(4) ———
1898. Some notes on observations in West Virginia. *In* Proc. 10th Ann. Meeting Assn. Econ. Ent. U. S. Dept. Agr., Div. Ent., Bul. 17, n. s., p. 44–49.

(5) Titus, E. S. G.
1904. Some preliminary notes on the clover-seed chalcis fly. *In* Some Miscell. Results of the Work of the Div. Ent. U. S. Dept. Agr., Div. Ent., Bul. 44, p. 77–80.

(6) Gahan, A. B.
1914. New Hymenoptera from North American. *In* Proc. U. S. Nat. Mus., v. 46, p. 431–443, pl. 39.

(7) ———
1915. Descriptions of new genera and species, with notes on parasitic Hymenoptera. *In* Proc. U. S. Nat. Mus., v. 48, p. 163.

(8) ———
1917. Descriptions of some new parasitic Hymenoptera. *In* Proc. U. S. Nat. Mus., v. 53, p. 195–217. May 26.

(9) Urbahns, T. D.
1916. Life history of Habrocytus medicaginis, a recently described parasite of the chalcis fly in alfalfa seed. *In* U. S. Dept. Agr., Jour. Agr. Research, v. 7, no. 4, p. 147–154, pl. 4, 1 fig.

(10) ———
1917. Tetrastichus bruchophagi, a recently described parasite of Bruchophagus funebris. *In* U. S. Dept. Agr., Jour. Agr. Research, v. 8, no. 7, p. 277–282, pl. 78.

(11) ———
1919. Life-history observations on four recently described parasites of Bruchophagus funebris. *In* U. S. Dept. Agr., Jour. Agr. Research, v. 16, no. 6, pl. 165–174, pl. 22–23, 8 fig.

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